Δp_i = Individual velocity head reading at traverse point ''i'', mm (in.) H_2O.
Δp_{std} = Velocity head measured by the standard pitot tube, cm (in.) H_2O.
Δp_s = Velocity head measured by the Type S pitot tube, cm (in.) H_2O.
3600 = Conversion Factor, sec/hr.
18.0 = Molecular weight of water, g/g-mole (lb/lb-mole).

12.2   Calculate T as follows:

$$T = \frac{\sum_{i=1}^{n}\sqrt{\Delta p_i + K}}{\sum_{i=1}^{n}\sqrt{\Delta p_i}} \qquad Eq.\ 2\text{-}1$$

12.3   Calculate D_e as follows:

$$D_e = \frac{2LW}{L + W} \qquad Eq.\ 2\text{-}2$$

12.4   Calibration of Type S Pitot Tube.

12.4.1   For each of the six pairs of Δp readings (i.e., three from side A and three from side B) obtained in Section 10.1.3, calculate the value of the Type S pitot tube coefficient according to Equation 2–3:

$$C_{p(s)} = C_{p(std)}\sqrt{\frac{\Delta p_{std}}{\Delta p}} \qquad Eq.\ 2\text{-}3$$

12.4.2   Calculate $\overline{C}_{p(A)}$, the mean A-side coefficient, and $\overline{C}_{p(B)}$, the mean B-side coefficient. Calculate the difference between these two average values.

12.4.3   Calculate the deviation of each of the three A-side values of $C_{p(s)}$ from $\overline{C}_{p(A)}$, and the deviation of each of the three B-side values of $C_{p(s)}$ from $\overline{C}_{p(B)}$, using Equation 2–4:

$$Deviation = C_{p(s)} - \overline{C}_{p(A\ or\ B)} \qquad Eq.\ 2\text{-}4$$

12.4.4   Calculate σ the average deviation from the mean, for both the A and B sides of the pitot tube. Use Equation 2–5:

$$\sigma_{A\ or\ B} = \frac{\sum_{i=1}^{3}\left|C_{p(s)} - \overline{C}_{p(A\ or\ B)}\right|}{3} \qquad Eq.\ 2\text{-}5$$

12.5   Molecular Weight of Stack Gas.

$$M_s = M_d\left(1 - B_{ws}\right) + 18.0\ B_{ws} \qquad Eq.\ 2\text{-}6 \qquad\qquad V_s = K_p C_p \sqrt{\Delta p_{avg}}\sqrt{\frac{T_{s(abs)}}{P_s M_s}} \qquad Eq.\ 2\text{-}7$$

12.6   Average Stack Gas Velocity.

$$34.97\frac{m}{sec}\left[\frac{(g/g\cdot mole)(mmHg)}{(^{\circ}K)(mmH_2O)}\right]^{\frac{1}{2}} \qquad Metric$$

$$85.49\frac{m}{sec}\left[\frac{(lb/lb\text{-}mole)(in.Hg)}{(^{\circ}R)(in.\ H_2O)}\right]^{\frac{1}{2}} \qquad English$$

12.7   Average Stack Gas Dry Volumetric Flow Rate.

$$Q = 3600\left(1 - B_{ws}\right)v_s A\left[\frac{T_{std}P_s}{T_{s(abs)}P_{std}}\right] \qquad Eq.\ 2\text{-}8$$

13.0   Method Performance [Reserved]

14.0   Pollution Prevention [Reserved]

15.0   Waste Management [Reserved]

16.0   References

1. Mark, L.S. Mechanical Engineers' Handbook. New York. McGraw-Hill Book Co., Inc. 1951.

2. Perry, J.H., ed. Chemical Engineers' Handbook. New York. McGraw-Hill Book Co., Inc. 1960.

3. Shigehara, R.T., W.F. Todd, and W.S. Smith. Significance of Errors in Stack Sampling Measurements. U.S. Environmental Protection Agency, Research Triangle Park, N.C. (Presented at the Annual Meeting of the Air Pollution Control Association, St. Louis, MO., June 14–19, 1970).

4. Standard Method for Sampling Stacks for Particulate Matter. In: 1971 Book of ASTM Standards, Part 23. Philadelphia, PA. 1971. ASTM Designation D 2928–71.

5. Vennard, J.K. Elementary Fluid Mechanics. New York. John Wiley and Sons, Inc. 1947.

6. Fluid Meters—Their Theory and Application. American Society of Mechanical Engineers, New York, N.Y. 1959.

7. ASHRAE Handbook of Fundamentals. 1972. p. 208.

8. Annual Book of ASTM Standards, Part 26. 1974. p. 648.

9. Vollaro, R.F. Guidelines for Type S Pitot Tube Calibration. U.S. Environmental Protection Agency, Research Triangle Park, N.C. (Presented at 1st Annual Meeting, Source Evaluation Society, Dayton, OH, September 18, 1975.)

10. Vollaro, R.F. A Type S Pitot Tube Calibration Study. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. July 1974.

11. Vollaro, R.F. The Effects of Impact Opening Misalignment on the Value of the Type S Pitot Tube Coefficient. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. October 1976.

12. Vollaro, R.F. Establishment of a Baseline Coefficient Value for Properly Constructed Type S Pitot Tubes. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. November 1976.

13. Vollaro, R.F. An Evaluation of Single-Velocity Calibration Technique as a Means of Determining Type S Pitot Tube Coefficients. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. August 1976.

14. Vollaro, R.F. The Use of Type S Pitot Tubes for the Measurement of Low Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. November 1976.

15. Smith, Marvin L. Velocity Calibration of EPA Type Source Sampling Probe. United Technologies Corporation, Pratt and Whitney Aircraft Division, East Hartford, CT. 1975.

16. Vollaro, R.F. Recommended Procedure for Sample Traverses in Ducts Smaller than 12 Inches in Diameter. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. November 1976.

17. Ower, E. and R.C. Pankhurst. The Measurement of Air Flow, 4th Ed. London, Pergamon Press. 1966.

18. Vollaro, R.F. A Survey of Commercially Available Instrumentation for the Measurement of Low-Range Gas Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. November 1976. (Unpublished Paper).

19. Gnyp, A.W., et al. An Experimental Investigation of the Effect of Pitot Tube-Sampling Probe Configurations on the Magnitude of the S Type Pitot Tube Coefficient for Commercially Available Source Sampling Probes. Prepared by the University of Windsor for the Ministry of the Environment, Toronto, Canada. February 1975.

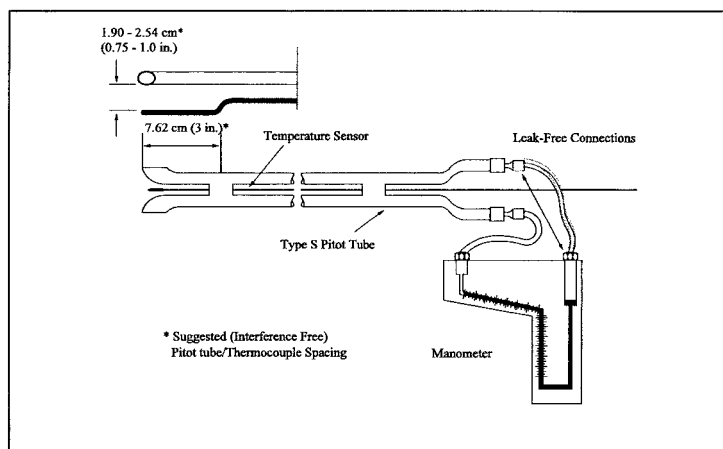*17.0   Tables, Diagrams, Flowcharts, and Validation Data*

Figure 2-1.   Type S Pitot Tube Manometer Assembly.

Transverse Tube Axis

A   B

Face Opening Planes

(a)

D_t A

A-Side Plane

Longitudinal Tube Axis

P_A
P_B

Note:
$1.05 D_t < P < 1.50 D_t$
$P_A = P_B$

B

B-Side Plane

(b)

(a) end view; face opening planes perpendicular to transverse axis;

(b) top view; face opening planes parellel to longitudinal axis;

A or B

(c)

(c) side view; both legs of equal length and centerlines coincident, when viewed fromboth sides. Baseline coefficient values of 0.84 may be assigned to pitot tubes constructed this way.
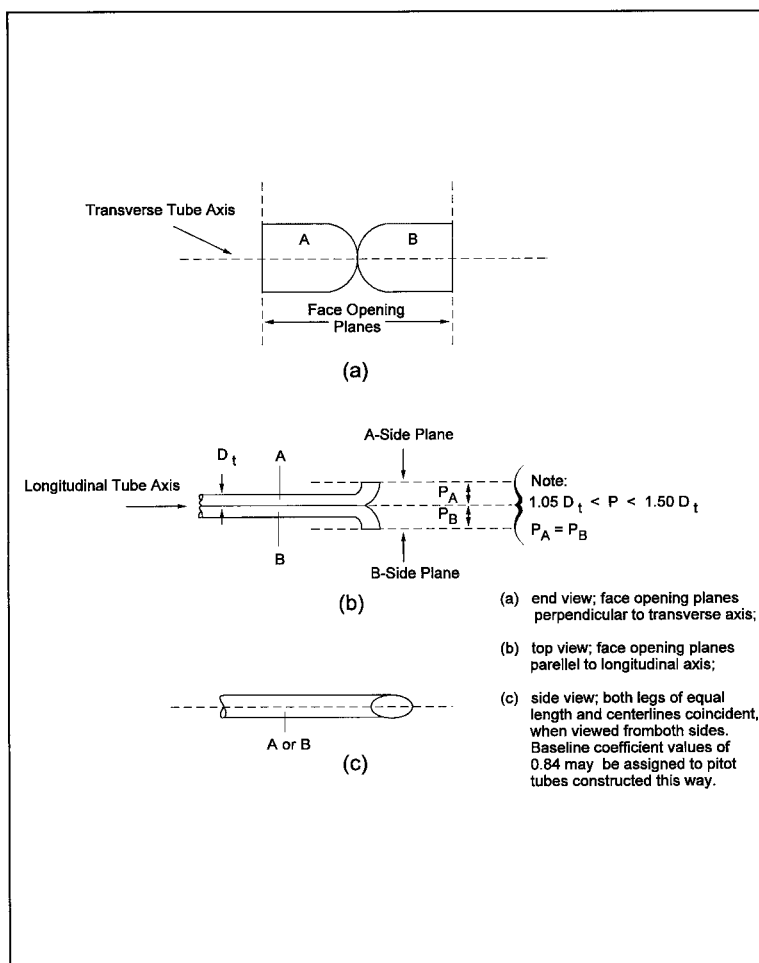
Figure 2-2. Properly Constructed Type S Pitot Tube.